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(54) **APPARATUS FOR AND METHOD OF VERIFYING ETCHING OF OPTICAL SERVO INFORMATION ON MAGNETIC MEDIA**

GERÄT UND VERFAHREN ZUR PRÜFUNG DER ÄTZUNG VON OPTISCHEN SERVO-INFORMATIONEN AUF MAGNETISCHEN MEDIEN

APPAREIL ET PROCEDE DE VERIFICATION DE L'ATTAQUE DES SERVO-PISTES OPTIQUES SUR DES SUPPORTS MAGNETIQUES

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Description

Fi ld of the Invention

This invention relates generally to information storage media having magnetic data tracks and optical servo tracks, and more particularly, the present invention relates to an apparatus for etching the optical servo tracks onto the magnetic medium and for verifying the etching of the optical servo tracks. It also relates to a method for verifying the etching.

Background of the Invention

So-called "floppy" disk memory systems for "desk top" sized computers are well known in the art. Such systems employ magnetic storage disks having a diameter of either 5.25 inches or 3.50 inches. Conventional magnetic storage disks for floppy disk drives have a track density ranging from forty-eight (48) to one hundred thirty-five (135) tracks per inch (TPI) (i.e., 1,9 to 5,3 tracks/mm). In contrast, optical storage disks for optical memory systems achieve track densities greater than 15,000 TPI (590 tracks/mm). The greater track density of optical disks is achieved by the use of optical servos that maintain fine positioning of the optical read\write head over the data tracks on the disk. Typically, concentric optical servo tracks are pre-recorded on the optical disk to guide the servo mechanism.

New advances in barium-ferrite magnetic media have allowed bit densities of magnetic storage disks to exceed the bit densities of optical disks. However, as mentioned above, track densities of magnetic media (48 - 135 TPI) are many times less than their optical counterparts. This limits the overall capacity of magnetic disks as compared to optical disks. Conventional magnetic disk systems employ a magnetic servo mechanism and magnetically pre-recorded servo tracks on the disks to guide the read\write head. Magnetic servo systems cannot provide the fine positioning that optical servo systems can provide.

Recently, floppy disk systems have been developed that combine magnetic disk recording techniques with the high track capacity optical servos found in optical disk systems. Such a system is described in AN INTRODUCTION TO THE INSITE 325 FLOPTICAL(R) DISK DRIVE, Godwin, in a paper presented at the SPIE Optical Data Storage Topical Meeting (1989). Essentially, an optical servo pattern is pre-recorded on a magnetic floppy disk. The optical servo pattern typically consists of a large number of equally spaced concentric tracks about the rotational axis of the disk. Data is stored in the magnetic "tracks" between the optical servo tracks using conventional magnetic recording techniques. An optical servo mechanism is provided to guide th magnetic read\write head accurately over the data between the optical servo tracks. By utilizing optical servo techniques, much higher track densities are achievable on the relatively inexpensiv r movable magnetic medium.

As mentioned, the optical servo pattern typically consists of a large number of qually spaced conc ntric tracks about the rotational axis of th disk. As disclos d in U.S. Pat nt No. 4,961,123, each track may be a singl continuous groove (Fig. 3), a plurality of equally spaced circular pits (Fig. 8), or a plurality of short equally spaced grooves or stitches (Fig. 9). Various methods and systems exist for inscribing the optical servo tracks on the magnetic medium.

For example, U.S. Patent No. 5,067,039, entitled "High Track Density Magnetic Media with Pitted Optical Servo Tracks and Method for Stamping the Tracks on the Media," discloses a method for "stamping" the servo tracks on the magnetic medium. Essentially a master stamping disk is produced bearing a template of the optical servo pattern. This master disk is then pressed against the magnetic floppy disk under a pressure of several tons per square inch. The significant amount of pressure transfers the servo track pattern from the master disk to the floppy.

U.S. Patent No. 4,633,451, entitled "Optical Servo for Magnetic Disks," discloses a method of providing optical servo information on a magnetic medium consisting of a multi-layer film. The optical servo tracks are formed on the multi-layer film by laser heating the structure to cause a reaction or interdiffusion to occur between layers. The reaction produces a reflectivity contrast of about eight percent (8%) between exposed and unexposed areas. Other methods for preparing the servo tracks are mentioned including contact printing, embossing, and lithography.

U.S. Patent No. 4,961,123, entitled "Magnetic Information Media Storage with Optical Servo Tracks," discloses a preferable method and apparatus for etching the pattern on a disk using a focused beam of light. The magnetic disk is placed on a platen/spindle assembly and rotated. A beam of light is focused to a small spot on the spinning disk. The focussed beam has sufficient intensity to ablate the disk surface at the point of incidence, thereby reducing the reflectivity of the surface at that point. The beam can be left on during an entire revolution to produce a continuous groove or can be modulated on and off through one revolution to produce a stitched pattern. This method has several advantages. First, the intensity of the focussed beam of light can be adjusted for different types of magnetic media. Secondly, different stitched patterns can be etched simply by varying the on-off time of the beam or by varying the speed of rotation of the disk. Additionally, there is no need to produce a master disk, as with the stamping method.

As mentioned above, the optical servo pattern often comprises a number of equally spaced concentric optical servo tracks about the rotational axis of the disk. A single disk may hav as many as 900 concentric servo tracks. Additionally, each optical servo track may b a continuous groove, or alternatively, may comprise a plu-

rality of equally spaced stitches. When a stitched patt rn is employed, the number of stitches in each optical s rvo track may exceed 1600 with each track having the same number of stitches. It is crucial for proper servo positioning that very stitch be sufficiently detectable by the servo optics. As mentioned, a preferred method of producing a stitched pattern is by focusing a beam of light on a rotating disk and modulating the beam on and off. The beam, when incident upon the surface of the disk and properly focused, has sufficient intensity to etch the surface thereby creating a stitch having reduced reflectivity.

It is possible, for a number of reasons, that one or more stitches are not properly etched. For example, the optics of the etching apparatus may become misaligned, dust particles may interfere with the incident beam of light, or the incident beam may not be properly focused upon the medium. It is critical for proper servo positioning that every stitch in each optical servo track be properly etched; one missing etch will ruin the entire disk. Thus, there exists a need for an apparatus and method for etching the surface of a magnetic medium and for verifying that proper etching occurred. The present invention satisfies this need.

Additionally, the width of the etched stitches is on the order of microns and must be maintained within tight tolerances. Stitch width can be affected by improper focussing of the incident beam. Thus, there also exists a need for an apparatus and method for imaging the etched spot on the surface of the medium and determining the size of the etched spot from the image in order to ascertain whether focus adjustment is necessary. The present invention satisfies this need as well.

Summary of the Invention

The present invention comprises an apparatus for etching a point on the surface of a magnetic medium to reduce the reflectivity of that point and for verifying that etching occurred. The apparatus comprises a light source for providing a collimated incident beam of light. A first lens situated in the path of the transmitted incident beam focuses the incident beam to a point on the surface of the magnetic medium. The focused incident beam reacts with the magnetic medium to reduce the reflectivity of the surface at that point. A portion of the focused incident beam is reflected, and the first lens collimates the reflected beam and directs the reflected beam back toward the light source. The apparatus further comprises means for separating the reflected beam from the incident beam and for deflecting the reflected beam. Detector means situated in the path of the deflected reflected beam measure the intensity of the reflected beam and compare the measured intensity to a threshold value. Proper etching is verified if the intensity of th reflected beam is not less than the threshold value.

According to a preferred mbodiment of the present invention, the detector means comprises a second lens situated in the path of the d flected reflected beam. An opaque screen is positioned substantially in the focal plane of the second lens. Th screen has a pin hole substantially at the focal point of the second lens and operates to block out un-focused rays of light emanating from the second lens. A photodetector is positioned on the side of the screen opposite the second lens and proximate the pin hole for producing a signal having a magnitude proportional to the intensity of the deflected reflected beam passing through the pin hole. In the preferred embodiment, the apparatus further comprises means for adjustably attenuating the reflected beam for protecting the photodetector from damage due to the intensity of the reflected beam during etching and for allowing the same photodetector to be used with various incident beam and reflected beam intensities.

Additionally, according to the preferred embodiment of the present invention, the means for separating and for deflecting the reflected beam comprises a polarizer positioned in the path of the incident beam between the light source and the first lens for linearly polarizing the incident beam in a first polarizing direction. A beam separator is positioned in the path of the incident beam between the polarizer and the first lens having means for transmitting light linearly polarized in the first polarizing direction and for deflecting light linearly polarized in a direction orthogonal to the first polarizing direction. Accordingly, the beam separator transmits the incident beam. Means positioned between the first lens and the beam separator alter the polarization of the reflected beam relative to the incident beam such that the reflected beam is linearly polarized in a direction orthogonal to the direction of polarization of the incident beam thereby causing the beam separator to deflect the reflected beam.

Preferably, the magnetic medium is positioned in the focal plane of the first lens. Additionally, the threshold value is adjustable for different types of magnetic media.

In the preferred embodiment of the present invention, the magnetic medium is a disc having a rotational axis and having concentric magnetic data tracks about the rotational axis. According to this preferred embodiment, the apparatus further comprises means for rotating the disc about its rotational axis, and means for modulating the light source on and off for consecutively etching a plurality of equally spaced stitches about the rotational axis of the medium. The means for rotating the disk comprises a spindle/platen assembly. The plurality of stitches define an optical servo track. The detector means is employed to verify each consecutively etched stitch in the track. The apparatus further comprises means for positioning the incident beam radially of the disc for etching each of a plurality of concentric optical servo tracks about the rotational axis of the disc.

According to another featur of the present invention, each optical servo track has a pre-det rmined stitch count and the apparatus further comprises a coun-

ter and means for incrementing the counter each time a stitch is verified. Means are also provided for comparing the contents of the count r to the pr -d termined stitch count. Proper etching of each optical servo track is verified when the contents of th counter equal the pre-determined stitch count for that track.

According to yet another feature of the present invention, the apparatus further comprises imaging means positioned in the path of the deflected reflected beam for generating from the reflected beam an image of the etched point on the surface of the medium. Means for processing the generated image to determine the size of the etched point are provided along with means for adjusting the focus of the first lens if the size of the etched point exceeds a pre-determined tolerance.

According to still another aspect of the present invention, the incident beam is aligned to the center of rotation of the spindle prior to etching the servo tracks.

The invention also comprises a method for verifying the etching.

Other features of the present invention will become evident from the following drawings and specification.

Brief Description of the Drawings

The foregoing summary, as well as the following detailed description of the preferred embodiment, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, there is shown in the drawings, an embodiment that is preferred, it being understood, however, that the invention is not limited to the specific methods and instrumentalities disclosed. In the drawings:

Figure 1 is a top view of a portion of a magnetic disk having concentric optical servo tracks each comprised of a plurality of equally spaced etched stitches;

Figure 2 is a block diagram of an apparatus for etching optical servo information on a magnetic medium, for verifying said etching, and for imaging the etched spot on the surface of the medium in accordance with the present invention;

Figure 3 is a top view of a centration device for aligning an incident beam;

Figure 4 is a cross-sectional view of the centration device of Figure 3 taken along line 4--4 of Figure 3;

Figure 5 is a block diagram of the apparatus of Figure 2 showing modifications to the apparatus for aligning the incident beam; and

Figures 6-8 graphically illustrate the signal output of the oscilloscope of Figure 5 during a beam alignment sequence.

Detailed Description of the Pref rred Embodim nt

Ref rring to the drawings in detail, wherein lik numerals indicate like elements throughout, there is shown in Figure 1 a top view of a portion of a magnetic disk 10 having conc ntric optical servo tracks 12, 14 about the rotational axis 16 of th disk 10. Each servo track 12, 14 is comprised of a plurality of equally spaced etched stitches 18. Concentric magnetic data tracks 20 lie between each adjacent pair of servo tracks 12, 14 for magnetically recording data on the disk 10. In the preferred embodiment, each disk has 900 concentric servo tracks and each servo track comprises 1666 equally spaced etched stitches. Each stitch is approximately 4.8 microns wide and the spacing between adjacent stitches in a same track is 20.4 microns. Since the inner radius of the disk is smaller than the outer radius, the length of the stitches in a given servo track increases from the inner to outer radius of the disk in order to maintain the same number of stitches in each track.

Referring to Figure 2, there is shown a preferred embodiment of an apparatus 39 for etching a point on the surface of a magnetic medium to reduce the reflectivity of the point and for verifying that proper etching of the point occurred. More particularly, the apparatus 39 is for etching a plurality of concentric optical servo tracks about the rotational axis of a magnetic storage disc, such as is shown in Figure 1, wherein each track comprises a plurality of equally spaced etched stitches, and for verifying the stitch count of each track.

As shown in Figure 2, the apparatus 39 comprises a light source 40 for providing a collimated incident beam of light 42. A polarizer 46 is positioned in the path of the incident beam for linearly polarizing the incident beam of light in a first polarizing direction. The direction of linear polarization, i.e., the first polarizing direction, is not critical. In the preferred embodiment, the light source 40 is a laser tuned to a wavelength suitable for etching the surface of the magnetic medium. Thus, the incident beam is highly collimated and monochromatic. Different wavelengths may be used with magnetic media having different characteristics. In the preferred embodiment, the polarizer 46 for linearly polarizing the incident beam comprises two brewster windows in the laser tube.

The apparatus 39 also comprises means for modulating the light source 40 on and off for consecutively etching the plurality of equally spaced stitches in each optical servo track. In the preferred embodiment, the means for modulating the light source on and off is an acousto-optical device 44. Acousto-optic modulators are described in Wilson & Hawkes, OPTOELECTRONICS: AN INTRODUCTION, pp. 111 to 116 (Prentice/Hall 1983). Although an acousto-optical device is employed in the preferred embodiment, any other suitable means for modulating the light source on and off may be employed, such as for example, a shutter mechanism (not shown) or beam deflector (not shown). Alternatively, the power input to the light source itself could be modulated on and off to produce a corresponding modulation of the incident beam.

Mirror 50 directs the linearly polarized incident beam through a beam separator 52. Beam s parator 52

of the present invention has means for transmitting light linearly polariz d in the first polarizing direction (as is the incident beam) and for deflecting light linearly polarized in a direction orthogonal to the first polarizing direction. In th pref rr d embodiment, the means for transmitting light linearly polarized in the first polarizing direction and for deflecting light polarized orthogonal thereto is a multilayer dielectric thin film laser line coating 53 positioned along the hypotenuse of the beam separator 52.

The beam separator 52 transmits the linearly polarized incident beam and mirrors 51, 55 direct the transmitted incident beam to a first lens 54. The first lens 54 focuses the incident beam to a point 57 on a magnetic storage disk 61 to be etched. A platen/spindle assembly 59 rotates the disk 61 about its rotational axis. The spindle 59 has a center pin 78 at the center of rotation of the spindle 59. The disk 61 has a center hub (not shown) which has a center hole (not shown). The disk 61 is placed on the spindle 59 with the center pin 78 through the center hole (not shown) of the disk hub (not shown). The first lens 54 is positioned such that the rotating disc lies substantially in the focal plane of the first lens 54. The focused incident beam reacts with the rotating magnetic medium 61 at the point 57 to create a stitch (not shown) on the medium 61 having reduced reflectivity. A portion of the focused incident beam is reflected. Since the incident beam is focused to a fine point on the magnetic medium, the reflected light effectively emanates from a point source. As described above, the rotating disk 61 lies in the focal plane of the lens 54, and therefore this point source of reflected light lies at the focal point of the first lens 54. Consequently, the lens 54 operates to collimate the reflected light and direct a reflected beam back toward the beam separator 52 via the mirrors 51, 55.

The apparatus 39 further comprises means for altering the polarization of the reflected beam relative to the incident beam prior to the reflected beam passing back through the beam separator 52 such that the reflected beam is linearly polarized in a direction orthogonal to the first polarizing direction of the incident beam. In the preferred embodiment, the means for altering the polarization of the reflected beam relative to the incident beam is a quarter-wave plate 56. Essentially, as the linearly polarized incident beam (polarized in the first polarizing direction) first passes from the mirror 50 through the beam separator 52 and then through the quarter-wave plate 56, the quarter-wave plate 56 transforms the incident beam from linear polarization in the first polarizing direction to circular polarization. Thus, when the incident beam strikes the magnetic medium 61 at the point 57, it is circularly polarized. Consequently, the reflected beam that is directed by the first lens 54 back toward the quarter-wave plate 56 and beam separator 52 is similarly circularly polarized. As the circularly polarized reflected beam passes back through the quarter-wave plate 56, the quarter-wave plate 56 transforms the circularly polarized reflected beam to linear polarization. However, the transformed reflected beam will be linearly polarized in a direction orthogonal to the first polarizing direction of the incident beam. Consequently, as mentioned above, the thin film laser line coating 53 along th hypotenuse of the beam separator 52 will deflect the reflected beam (the deflected reflected beam is indicated generally at 67).

The polarizer 46, beam separator 52 and quarter wave-plate 56 collectively comprise means for separating the reflected beam from the incident beam and for deflecting the reflected beam. It is understood by those skilled in the art that means other than those disclosed herein may be employed to separate and deflect the reflected beam. As used in the claims, the phrase "means for separating the reflected beam from the incident beam and for deflecting the reflected beam" is intended to encompass all such possibilities.

Referring still to Figure 2, the apparatus 39 further comprises detector means 60 situated in the path of the deflected reflected beam for measuring the intensity of the reflected beam, and for comparing the measured intensity to a threshold value. Verification of proper etching is established if the measured intensity of the reflected beam is not less than the threshold value. As those skilled in the art know, many different compositions may be used for magnetic storage media. Different types of magnetic media may be more or less susceptible to etching at a given incident beam intensity than others. Accordingly, in the preferred embodiment, the threshold value is adjustable for different types of magnetic media.

In the preferred embodiment, the detector means 60 comprises a second lens 62, an opaque screen 64 and a photodetector 66, all situated in the path of the deflected reflected beam. The screen 64 is positioned substantially in the focal plane of the second lens 62 and has a pin hole 69 located at the focal point of the second lens 62. The photodetector is positioned on the side of the screen 64 opposite the lens 62. The lens 62 focuses the deflected reflected beam onto the photodetector 66 which produces a signal having a magnitude proportional to the intensity of the reflected beam. For a single etch, the signal produced by the photodetector 66 is in the form of an electronic pulse. The opaque screen 64 blocks out any unfocused rays of light.

The apparatus 39 further comprises means for adjustably attenuating the reflected beam for protecting the photodetector 66 from damage due to the intensity of the reflected beam during etching and for allowing the same photodetector 66 to be used with various incident beam and reflected beam intensities. In the preferred embodiment, the means for attenuating the reflected beam is a standard optical beam attenuator 68 situated in the path of the deflected reflected beam between the beam separator 52 and the second lens 62. The degree of attenuation may be automatically adjusted by a computer 74 coupled to the attenuator 68.

The photodetector 66 is coupled to pulse condition-

ing and threshold circuitry 70 for comparing the magnitude of the pulse to the threshold valu . Th threshold circuitry 70 provides an indication of- verification when the pulse amplitude exc eds the thr shold. As those skilled in the art will appreciat , puls conditioning and threshold circuitry 70 of the type employed herein are well known to those skilled in the art and may be implemented in many ways. Without deviating from the spirit and scope of the present invention, the threshold circuitry 70 of the present invention is not limited to any one implementation.

Although the apparatus 39 and method described herein may be employed to verify any etched pattem, the apparatus 39 is preferably employed to etch and verify an optical servo pattem such as that shown in Figure 1. As described above, the servo pattern shown in Figure 1 comprises a plurality of equally spaced concentric optical servo tracks about the rotational axis of the disk. In the preferred embodiment, each disk has 900 concentric servo tracks and each servo track comprises 1666 equally spaced etched stitches. Referring to Figure 2, the apparatus 39 furtner comprises means (shown generally at 71) for moving the incident beam radially of the disc for etching each of the plurality of concentric tracks. Thus, the beam is moved radially of the disk during the etching process as indicated by the arrows in Figure 2. A preferred method of moving the beam radially of the disk is disclosed in EP-A-0 645 044 entitled "Steering Laser Beam While Etching Optical Servo Tracks for Magnetic Disks."

As mentioned previously, in addition to verifying that a single etch occurred, the apparatus 39 may be employed to verify the stitch count of each optical servo track. To this end, the apparatus 39 further comprises a counter 72 coupled to the threshold electronics 70 for incrementing the counter 72 each time a stitch is verified (i.e., when the measured intensity of the reflected beam for that stitch exceeds the threshold value). In the preferred embodiment, a computer 74 is coupled to the counter 72 for comparing the contents of the counter 72 to an expected, pre-determined stitch count after each track is etched. The counter 72 is reset to zero before etching each track.

Altematively, rather than verifying the stitch count of each track, the apparatus 39 may be employed to verify the total stitch count for the entire disk. For this operation, the counter 72 would only be reset prior to etching the first track of each disk.

In use, the light source 40 provides a collimated incident beam of light that passes through modulator 44 which modulates the incident beam on an off at a rate sufficient to achieve the desired stitch count as the magnetic disk 61 rotates on the platen/spindle assembly 59. The incident beam is linearly polarized in the first polarizing direction. The linearly polarized beam th n passes through the beam separator 52 and through the quarter wave plate 56, the latter transforming the linearly polarized incident beam to circular polarization. Th circularly polarized incident beam is then focused to a point 57 on the rotating magnetic medium 61 by th first lens 54. As the beam modulates on and off, it reacts with the magnetic medium 61 as the medium 61 rotates past the point of incidenc 57 of the beam thereby creating consecutive stitches having reduced reflectivity. The first lens 54 and mirror 55 are moved radially over the surface of the rotating medium 61 for etching each of the 900 concentric optical servo tracks.

As each stitch is etched, a portion of the incident beam is reflected by the magnetic medium. As previously described, the reflected light is collimated by the first lens 54 and directed back toward the quarter-wave plate 56. The reflected beam is circularly polarized prior to passing through the plate 56. As the reflected beam passes through the plate 56, the plate 56 transforms the beam from circular polarization to linear polarization. The direction of linear polarization of the reflected beam, however, will be orthogonal to the first polarizing direction of the incident beam. Consequently, the reflected beam is deflected as it passes through the beam separator 52 by the thin film laser line coating 53. The deflected reflected beam 67 is directed to the second lens 62 where it is focused through the pin-hole 69 in the opaque screen 64 and onto the photodetector 66. Essentially, first lens 54 and second lens 62 operate to image the etched point 57 onto the photodetector 66. As each stitch is etched, the photodetector 66 produces a pulse having an amplitude proportional to the intensity of the reflected beam for that stitch. The amplitude of the pulse is then compared to a threshold. The threshold is established such that if the amplitude of the pulse (i. e., the intensity of the reflected beam) equals or exceeds the threshold, then the incident beam had sufficient intensity to properly etch the stitch. Thus, in this manner, the apparatus 39 verifies the etching of each stitch. The counter 72 maintains a count of each pulse that satisfies the threshold. Each time the disk rotates through one revolution, the counter 72 is examined to ensure that the number of verified stitches equals the expected stitch count for the track. Thus, the present invention is directed to an apparatus and method for etching the surface of a magnetic medium and for verifying that etching occurred.

In accordance with another feature of the present invention, the apparatus 39 further comprises imaging means positioned in the path of the deflected reflected beam for generating from the reflected beam an image of the etched point 57 on the surface of the medium 61. In the preferred embodiment, the imaging means comprises a CCD camera 76 having a long focal length lens such that the image of the etched point occupies a large portion of the camera's field-of-view. A standard beam splitter 70 is provided for splitting the deflected reflected beam so that both v rification and imaging can be performed simultaneously. Although the preferred embodiment employs a CCD camera 76, any suitable imaging device may b employed.

The camera 76 is coupled to the computer 74 which provides means for processing the generated image to determine the size of th etched point. The computer 74 may also provide means for processing the generat d image to examine the energy profil of the focussed spot. The means for processing the generated image may comprise a standard frame-grabber add-in card (not shown) and associated image processing software (not shown); however, any suitable processing means may be employed without deviating from the spirit and scope of the present invention.

Recall from the background section that the width of the etched stitches is on the order of microns and must be maintained within tight tolerances. Often the culprit of excessive stitch width is an improperly focused incident beam. Accordingly, the apparatus 39 further comprises means (not shown) for adjusting the focus of the first lens 54 if the size of the etched point, as determined by the computer 74, exceeds a pre-determined tolerance. The means for adjusting the focus of the first lens 54 may comprise a manual focusing mechanism (not shown) that an operator would adjust in response to an indication from the computer 74 that the size of the etched point 57 is too large. Alternatively, the computer 74 and accompanying hardware (not shown) may provide automatic adjustment of the focus of the first lens 54.

In accordance with yet another aspect of the present invention, the incident beam is aligned to the center of rotation of the spindle 59 prior to etching the servo tracks. Alignment is necessary to ensure accurately known radii of the servo tracks and to maintain accurate angular positioning of the stitches relative to a fixed angular index from the outer track to inner track.

Figure 3 is a top view of a centration device 80 used to facilitate alignment of the incident beam with the center of rotation of the spindle 59. The centration device 80 comprises a base portion 81 and a finely ruled surface 82 secured to the top of the device 80. The finely ruled surface 82 may be a diffraction grating, a Ronchi ruling, or any other surface with closely spaced markings (i.e., less than 10 microns) that exibit spatially repeating differences in optical contrast. In the preferred embodiment, the surface 82 has 3000 lines per inch scribed on it.

Figure 4 is a cross-sectional view of the centration device 80 taken along line 4--4 of Figure 3. As shown, the device 80 further comprises a center hole 84 which engages with the center pin 78 of the spindle 59 for mounting the finely ruled surface 82 on the spindle 59 proximate the center of rotation. The ruled surface 82 is placed and secured in a milled portion 86 of the base 81. An alignment hole (not shown) may also be provided in the base 81 for engaging with an alignment pin (not shown) on the spindle. Th alignment pin and corresponding alignment hole would operate to lock the device 80 in a fixed position during rotation so that the surface 82 does not move relative to the spindle 59.

Referring now to Figure 5, modifications to apparatus 39 are shown for aligning the incident beam to the center of rotation of the spindle 59. As shown, a shaft encoder 88 is coupled to the spindle 59. The shaft encoder 88 outputs a pulse once for every revolution of the spindle 59. One trace of an oscilloscope 90 is coupled to the output of photodetector 66 for displaying the photodetector output. The oscilloscope 90 is sync/triggered with the output of the shaft encoder 88.

To align the incident beam to the center of rotation of the spindle 59, the centration device 80, and thus the finely ruled surface 82, is mounted on the spindle 59 proximate the center of rotation of the spindle 59, as best shown in Figure 5. The finely ruled surface 82 is then rotated on the spindle 59. A linearly polarized incident beam of light is generated by the laser 40. The intensity of the beam is set at a level that will not etch the ruled surface 82. The beam passes through modulator 44. Mirror 50 directs the linearly polarized incident beam through the beam separator 52. The beam then passes through the quarter-wave plate 56 which transforms the incident beam from linear to circular polarization. Mirrors 51, 55 then direct the incident beam to the first lens 54 which focuses the incident beam to a point 79 on the rotating surface 82. The optics 55, 54 are initially positioned by the operator at what the operator believes to be the center of rotation of the spindle 59.

A portion of the focused incident beam is reflected. Since the incident beam is focused to a fine point on the rotating surface 82, the reflected light effectively emanates from a point source. Thus, the lens 54 operates to collimate the reflected light and direct a reflected beam back toward the beam separator 52 via the mirrors 51, 55.

As the reflected beam passes back through the quarter-wave plate 56 via mirrors 51, 55, the beam separator 52 deflects the reflected beam to the detector means 60. Lens 62 focuses the reflected beam through the pin-hole 69 and onto the photodetector 66 which continuously measures the intensity of the reflected beam. Since the finely ruled surface 82 is constantly rotating, the intensity of the reflection is not steady, but rather oscillates at a frequency that depends on the distance of the beam from the center of rotation of the spindle 59. Thus, the photodetector 66 produces a periodic signal having a frequency indicative of beam position relative to the center of rotation of the spindle.

The signal is displayed on the oscilloscope 90. Because the oscilloscope 90 is triggered by the output of the shaft encoder 88, the scope 90 displays the intensity of the reflected beam over a time equal to one revolution of the spindle 59. To obtain maximum centration of the beam, the operator mechanically adjusts the position of the optics 55, 54 parallel to the spindle 59 until the signal indicates maximum centration. Higher frequency oscillations of the displayed signal indicate greater distance of the beam from the center of rotation of the spindle. Figures 6 through 8 illustrate a typical beam alignm nt

sequence.

In Figure 6, the optics (not shown) have been initially positioned such that the incident beam is focused to a spot 79 on the ruled surface 82 at a r latively large distance from th center of rotation 92 of the spindle (not shown). Accordingly, the displayed signal 94 from the photodetector 66 has a high frequency. As illustrated in Figure 7, as the incident beam is moved closer to the center of rotation 92, the frequency of the displayed signal 94 begins to decrease. Figure 8 depicts the displayed signal 94 when the incident beam is at maximum centration, i.e., is aligned with the center of rotation of the spindle.

From the foregoing description it can be seen that the present invention comprises an apparatus for and method of etching the surface of a magnetic medium and for verifying that proper etching occurred. More particularly, the present invention is directed to an apparatus for etching a plurality of concentric optical servo tracks about the rotational axis of a magnetic disk having concentric magnetic data tracks wherein each optical servo track comprises a plurality of equally spaced etched stitches, and for verifying the stitch count of each optical servo track. In accordance with another feature of the present invention, the apparatus may additionally be employed to determine the size of the etched spot on the surface of the medium. In accordance with yet another aspect of the present invention, the incident beam is aligned to the center of rotation of the spindle prior to etching the servo tracks. It will be appreciated by those skilled in the art that changes could be made to the embodiment described above without departing from the broad inventive concepts thereof. It is understood, therefore, that this invention is not limited to the particular embodiment disclosed, but is intended to cover all modifications which are within the scope of the invention as defined by the appended claims.

Claims

1. An apparatus for etching a point on the surface of a magnetic medium to reduce the reflectivity of said point and for verifying said etching, comprising:

   a light source (40) for providing a collimated incident beam of light;
   a first lens (54) situated in the path of the transmitted incident beam for focusing the incident beam to a point on the surface of the magnetic medium (61), the focused incident beam reacting with the magnetic medium to reduce the reflectivity of the surface at that point, a portion of the focused incident beam being reflected, said first lens (54) collimating the reflected beam and directing the reflected beam back toward the light sourc (40);
   means (53) for s parating the reflected beam from the incident beam and for deflecting the r flected beam; and
   detector means (60) situated in th path of the deflected reflected beam for measuring the intensity of the reflected beam, and for comparing the measured intensity to a threshold value, whereby proper etching is verified if the intensity of the reflected beam is not less than the threshold value.

2. The apparatus of claim 1 wherein the means for separating and for deflecting the reflected beam comprises:

   a polarizer (46) positioned in the path of the incident beam between the light source (40) and the first lens (54) for linearly polarizing the incident beam in a first polarizing direction;
   a beam separator (52) positioned in the path of the incident beam between the polarizer and the first lens (54) having means for transmitting light linearly polarized in the first polarizing direction and for deflecting light linearly polarized in a direction orthogonal to the first polarizing direction, the beam separator (52) transmitting the incident beam; and
   means (56) positioned between the first lens (54) and the beam separator (52) for altering the polarization of the reflected beam relative to the incident beam such that the reflected beam is linearly polarized in a direction orthogonal to the direction of polarization of the incident beam thereby causing the beam separator (52) to deflect the reflected beam.

3. The apparatus of claim 1 or 2 wherein the magnetic medium (61) is positioned in the focal plane of the first lens (54).

4. The apparatus of any of claims 1 to 3 further comprising:

   imaging means (76) positioned in the path of the deflected reflected beam for generating from the reflected beam an image of the etched point on the surface of the medium; and
   means (74) for processing the generated image to determine the size of the etched point; and
   means for adjusting the focus of the first lens (54) if the size of the etched point exceeds a pre-determined tolerance.

5. The apparatus of any of claims 1 to 4 wherein the magnetic medium (61) is a disc (10) having a rotational axis (16) and having concentric magnetic data tracks (20) about said rotational axis (16), and wherein the disk (10) is positioned substantially in the focal plane of the first lens (54), and wherein the

apparatus further comprises:

means (59) for rotating the disc about the rotational axis thereof;
means (44) for modulating the light source (40) on and off for consecutively etching a plurality of equally spaced stitches about the rotational axis (16) of the medium (61), said plurality of stitches defining an optical servo track (12, 14), said detector means (60) for verifying each consecutively etched stitch in the track; and
means for moving the incident beam radially of the disc for etching each of a plurality of concentric optical servo tracks about the rotational axis of the disc.

6. The apparatus of claim 5 wherein each optical servo track (12,14) has a pre-determined stitch count and wherein the apparatus further comprises:

a counter (72);
means (70) for incrementing the counter (72) each time a stitch is verified; and
means (74) for comparing the contents of the counter (72) to the pre-determined stitch count, whereby proper etching of each optical servo track is verified when the contents of the counter (72) equal the pre-determined stitch count.

7. The apparatus of any of claims 1 to 6 wherein the detector means (60) comprises:

a second lens (62) situated in the path of the deflected reflected beam;
an opaque screen (64) positioned substantially in the focal plane of the second lens (62) and having a pin hole (69) substantially at the focal point of the second lens (62), said screen (64) for blocking out unfocused rays of light emanating from the second lens (62); and
a photodetector (66) positioned on the side of the screen (64) opposite the second lens (62) and proximate the pin hole (69) for producing a signal having a magnitude proportional to the intensity of the deflected reflected beam passing through the pin hole (69).

8. The apparatus of claim 7 further comprising means for adjustably attenuating the reflected beam for protecting the photodetector (66) from damage due the intensity of the reflected beam during etching and for allowing the same photodetector (66) to be used with various incident beam and reflected beam intensities.

9. An apparatus for tching a plurality of concentric optical servo tracks (12, 14) about the rotational axis (16) of a magnetic storage disc (61) having conc ntric magnetic data tracks (20) about said rotational axis (16), wherein each optical servo track (12, 14) comprises a plurality of qually spaced etched stitches (18), and for verifying the stitch count of each track, comprising:

means (59) for rotating the disc about the rotational axis thereof;
a light source (40) for providing a collimated incident beam of light;
means (44) for modulating the light source on and off for consecutively etching the plurality of equally spaced stitches in each optical servo track;
a polarizer (46) situated in the path of the incident beam for linearly polarizing the incident beam in a first polarizing direction;
a beam separator (52) situated in the path of the incident beam having means for transmitting light linearly polarized in the first polarizing direction and for deflecting light linearly polarized in a direction orthogonal to the first polarizing direction, the beam separator (52) transmitting the incident beam;
a first lens (54) situated in the path of the transmitted incident beam for focusing the incident beam to a point on the magnetic disc, the first lens (54) being positioned such that the disc lies substantially in the focal plane of the first lens (54), the focused incident beam reacting with the rotating magnetic medium (61) to create a stitch on the medium having reduced reflectivity,
a portion of the focused incident beam being reflected, said first lens (54) collimating the reflected beam and directing the reflected beam back toward the beam separator (52);
means (56) for altering the polarization of the reflected beam relative to the incident beam prior to passing back through the beam separator (52) such that the reflected beam is linearly polarized in a direction orthogonal to the first polarizing direction of the incident beam thereby causing the beam separator (52) to deflect the reflected beam;
detector means (60) situated in the path of the deflected reflected beam for measuring the intensity of the reflected beam, and for comparing the measured intensity to a threshold value, and for incrementing a counter (72) when the measured intensity is not less than the threshold value;
means for moving the incident beam radially of the disc for etching each of the plurality of concentric optical s rvo tracks.

10. Th apparatus of claim 9 wherein the detector means (60) comprises:

a second lens (62) situated in the path of the deflected reflected beam;
an opaque screen (64) positioned substantially in the focal plane of the second lens (62) and having a pin hole (69) substantially at the focal point of the second lens (62), said screen (64) for blocking out unfocused rays of light emanating from the second lens (62); and
a photodetector (66) positioned on the side of the screen (64) opposite the second lens (62) and proximate the pin hole (69) for producing a signal having a magnitude proportional to the intensity of the focused reflected beam passing through the pin hole (69).

11. The apparatus of any of claims 2 to 10 wherein the means for transmitting light linearly polarized in the first polarizing direction and for deflecting light linearly polarized in a direction orthogonal to the first polarizing direction comprises a multilayer dielectric thin film laser line coating.

12. A method for verifying each stitch in an apparatus for etching a plurality of concentric optical servo tracks (12, 14) about the rotational axis (16) of a magnetic storage disc (61) having concentric magnetic data tracks (20) about the rotational axis (16), wherein each optical servo track (12, 14) comprises a plurality of equally spaced stitches (18) and wherein the stitches are consecutively etched by modulating on and off an incident beam of light focused on said disc by a lens (54) as said disc rotates, and wherein a portion of said incident beam is reflected off the disk during the etching of each stitch, said method comprising the steps of:

a) collimating the reflected portion of the incident beam to produce a reflected beam;
b) separating the reflected beam from the incident beam;
c) measuring the intensity of the reflected beam and comparing the measured intensity to a threshold value; and
d) providing an indication of verification if the measured intensity is not less than the threshold value.

13. The method of claim 12 wherein step (b) comprises the following steps:

i) linearly polarizing the incident beam in a first polarizing direction prior to focussing said incident beam on said disc;
ii) altering the polarization of the reflected beam relativ to the incident beam such that the reflected beam is linearly polarized in a direction orthogonal to th first polarizing direction of the incident beam; and
iii) directing the incident beam and the reflected beam through a beam splitter having means for transmitting a beam of light linearly polarized in the first polarizing direction and for deflecting light linearly polarized in a direction orthogonal to the first polarizing direction, whereby the incident beam is transmitted through the beam splitter and the reflected beam is deflected.

14. The method of claim 13 further comprising the steps of:

i) repeatedly generating from the reflected beam an image of the etched point on the surface of the medium;
ii) processing the generated image to determine the size of the etched point; and
iii) adjusting the focus of the lens if the size of the etched point exceeds a pre-determined tolerance.

15. The method of any of claims 12 to 14 wherein said apparatus for etching further comprises:

optics (40) for generating said incident beam of light for etching said optical servo tracks; and
a spindle (59) having a center of rotation for rotating said disk in proximity to said optics, said method further comprising aligning the incident beam to the center of rotation of said spindle prior to etching said servo tracks, including the steps of:
mounting a finely ruled surface on said spindle proximate the center of rotation of said spindle;
rotating said finely ruled surface on said spindle;
focusing said incident beam onto said rotating finely ruled surface, a portion of said incident beam being reflected from said ruled surface and forming a reflected beam;
continuously measuring the intensity of the reflected beam to produce a periodic signal having a frequency indicative of beam position relative to said center of rotation of said spindle;
mechanically adjusting the position of said optics parallel to said spindle until said signal indicates maximum centration, and
preferably, further comprising the step of separating the reflected beam from the incident beam prior to measuring the intensity of the reflected beam.

Patentansprüche

1. Vorrichtung zum Ätzen eines Punktes auf der Oberfläche eines magnetischen Mediums, um die Reflektivität des Punktes zu reduzieren, und zum Ve-

rifizieren der Ätzung, mit:

einer Lichtquell (40) zum Erzeugen eines kollimierten Lichteinfallsstrahls;
einer ersten in dem Pfad des durchgelassenen Einfallsstrahls angeordneten Linse (54) zum Fokussieren des Einfallsstrahls auf einen Punkt auf der Oberfläche des magnetischen Mediums (61), wobei der fokussierte Einfallsstrahl mit dem magnetischen Medium so reagiert, daß er die Reflektivität der Oberfläche an diesem Punkt verringert, ein Teil des fokussierten Einfallsstrahls reflektiert wird, die erste Linse (54) den reflektierten Strahl kollimiert und den reflektierten Strahl zu der Lichtquelle (40) zurückleitet;
einer Einrichtung (53) zum Trennen des reflektierten Strahls von dem Einfallsstrahl und zum Ablenken des reflektierten Strahls; und
einer in dem Pfad des abgelenkten reflektierten Strahls angeordneten Detektoreinrichtung (60) zum Messen der Intensität des reflektierten Strahls und zum Vergleichen der gemessenen Intensität mit einem Schwellenwert, wodurch eine einwandfreie Ätzung verifiziert wird, wenn die Intensität des reflektierten Strahls nicht geringer als der Schwellenwert ist.

2. Vorrichtung nach Anspruch 1, wobei die Einrichtung zum Trennen und zum Ablenken des reflektierten Strahls aufweist:

einen Polarisator (46), der in dem Pfad des Einfallsstrahls zwischen der Lichtquelle (40) und der ersten Linse (54) zum linearen Polarisieren des Einfallsstrahls in einer ersten Polarisationsrichtung angeordnet ist;
einen Strahltrenner (52), der in dem Pfad des Einfallsstrahls zwischen dem Polarisator und der ersten Linse (54) angeordnet ist, mit einer Einrichtung, um in der ersten Polarisationsrichtung linear polarisiertes Licht durchzulassen und um in einer Richtung senkrecht zu der ersten Polarisationsrichtung linear polarisiertes Licht abzulenken, wobei der Strahltrenner (52) den Einfallsstrahl passieren läßt; und
eine zwischen der ersten Linse (54) und dem Strahltrenner (52) angeordnete Einrichtung (56) zum Ändern der Polarisationsrichtung des reflektierten Strahls in Bezug auf den Einfallsstrahl in der Weise, daß der reflektierte Strahl in einer Richtung senkrecht zu der Polarisation des Einfallsstrahls linear polarisiert wird, wodurch der Strahltrenner (52) dazu veranlaßt wird, den reflektierten Strahl abzulenken.

3. Vorrichtung nach Anspruch 1 oder 2, wobei das magnetisch Medium (61) in der Brenn bene der ersten Linse (54) angeordnet ist.

4. Vorrichtung nach inem der Ansprüche 1 bis 3, ferner mit:

einer Abbildungseinrichtung (76) in dem Pfad des abgelenkten, reflektierten Strahls zum Erzeugen einer Abbildung des geätzten Punktes auf der Oberfläche des Mediums aus dem reflektierten Strahl;
einer Einrichtung (74) zum Verarbeiten der erzeugten Abbildung zur Bestimmung der Größe des geätzten Punktes; und
einer Einrichtung zum Einstellen des Fokusses der ersten Linse (54), wenn die Größe des geätzten Punktes einen vorbestimmten Toleranzwert überschreitet.

5. Vorrichtung nach einem der Ansprüche 1 bis 4, wobei das magnetische Medium (61) eine Platte (10) mit einer Rotationsachse (16) und mit konzentrischen magnetischen Datenspuren (20) um die Rotationsachse (16) ist, und wobei die Platte (10) im wesentlichen in der Brennebene der ersten Linse (54) angeordnet ist, und wobei die Vorrichtung ferner aufweist:

eine Einrichtung (59) zum Drehen der Platte um ihre Rotationsachse;
eine Einrichtung (44) zum Ein/Aus-Modulieren der Lichtquelle (40), um mehrere in gleichen Abständen angeordnete Striche um die Rotationsachse (16) des Mediums (61) aufeinanderfolgend zu ätzen, wobei die mehreren Striche eine optische Servospur (12, 14) bilden, und die Detektoreinrichtung (60) jeden der aufeinanderfolgend in der Spur geätzten Striche verifiziert; und
eine Einrichtung zum Bewegen des Einfallsstrahls radial zu der Platte, um jede von mehreren konzentrischen optischen Servospuren um die Rotationsachse der Platte zu ätzen.

6. Vorrichtung nach Anspruch 5, wobei jede optische Servospur (12, 14) eine vorbestimmte Strichanzahl aufweist, und wobei die Vorrichtung ferner aufweist:

einen Zähler (72);
eine Einrichtung (70) zum Inkrementieren des Zählers (72) jedesmal dann, wenn ein Strich verifiziert ist; und
eine Einrichtung (74) zum Vergleichen der Inhalte des Zählers (72) mit der vorbestimmten Strichanzahl, wodurch eine einwandfreie Ätzung jeder optischen Servospur verifiziert wird, wenn die Inhalte des Zählers (72) gleich einer vorbestimmten Strichanzahl sind.

7. Vorrichtung nach einem der Ansprüche 1 bis 6, wobei die Detektoreinrichtung (60) aufweist:

eine zweite Linse (62), die in dem Pfad des abgelenkten reflektierten Strahls angeordnet ist; einen undurchsichtigen Schirm (64), der im wesentlichen in der Brennebene der zweiten Linse (62) angeordnet ist, und eine im wesentlichen an dem Brennpunkt der zweiten Linse (62) angeordnete Blende (69) aufweist, wobei der Schirm (64) von der zweiten Linse (62) ausgehende nicht fokussierte Lichtstrahlen ausfiltert; und
einen Photodetektor (66), der auf der der zweiten Linse (62) gegenüberliegenden Seite des Schirms (64) und nahe an der Blende (69) positioniert ist, um ein Signal mit einer Größe proportional zu der Intensität des die Blende (69) passierenden abgelenkten reflektierten Lichtstrahls zu erzeugen.

8. Vorrichtung nach Anspruch 7, welche ferner eine Einrichtung zum einstellbaren Abschwächen des reflektierten Strahls für den Schutz des Photodetektors (66) vor Beschädigung aufgrund der Intensität des reflektierten Strahls während des Ätzvorgangs und zum Ermöglichen der Verwendung desselben Photodetektors (66) bei verschiedenen Intensitäten des Einfallsstrahls und des reflektierten Strahls aufweist.

9. Vorrichtung zum Ätzen mehrerer konzentrischer optischer Servospuren (12, 14) um die Rotationsachse (16) einer magnetischen Speicherplatte (61) mit konzentrischen magnetischen Datenspuren (20) um die Rotationsachse (16), wobei jede optische Servospur (12, 14) mehrere in gleichen Abständen angeordnete Striche (18) aufweist, und zum Verifizieren der Strichanzahl jeder Spur, mit:

einer Einrichtung (59) zum Drehen der Platte um ihre Rotationsachse;
einer Lichtquelle (40) zum Erzeugen eines kollimierten Lichteinfallsstrahls;
einer Einrichtung (44) zum Ein/Aus-Modulieren der Lichtquelle, um die mehreren in gleichen Abständen angeordneten Striche aufeinanderfolgend in jeder optischen Servospur zu ätzen;
einem Polarisator (46), der in dem Pfad des Einfallsstrahls zum linearen Polarisieren des einfallenden Strahls in einer ersten Polarisationsrichtung angeordnet ist;
einen Strahltrenner (52), der in dem Pfad des Einfallsstrahls angeordnet ist und eine Einrichtung aufweist, um in der ersten Polarisationsrichtung linear polarisiertes Licht durchzulassen und in einer Richtung senkrecht zu d r rsten Polarisationsrichtung linear polarisiertes Licht abzulenken, wobei der Strahltrenner (52) den Einfallsstrahl passieren läßt;
ein r in dem Pfad des durchg lassenen Einfallsstrahls angeordneten rst n Linse (54) zum Fokussieren den einfallenden Strahls auf einen Punkt auf der Oberfläche der magnetischen Platte, wobei die erste Linse (54) so angeordnet ist, daß die Platte im wesentlichen in der Brennebene der ersten Linse (54) angeordnet ist, der fokussierte Einfallsstrahl mit dem rotierenden magnetischen Medium (61) so reagiert, daß er einen Strich auf dem Medium mit reduzierter Reflektivität erzeugt,
wobei ein Teil des fokussierten Einfallsstrahls reflektiert wird, die erste Linse (54) den reflektierten Strahl kollimiert und den reflektierten Strahl zu dem Strahlteiler (52) zurückleitet;
einer Einrichtung (56) zum Ändern der Polarisationsrichtung des reflektierten Strahls in Bezug auf den Einfallsstrahl vor dem Durchtritt durch den Strahlteiler (52) in der Weise, daß der reflektierte Strahl in einer Richtung senkrecht zu der ersten Polarisationsrichtung des Einfallsstrahls linear polarisiert wird, wodurch der Strahltrenner (52) dazu veranlaßt wird, den reflektierten Strahl abzulenken;
einer Detektoreinrichtung (60), die in dem Pfad des abgelenkten reflektierten Strahls angeordnet ist, zum Messen der Intensität des reflektierten Strahls und zum Vergleichen der gemessenen Intensität mit einem Schwellenwert und zum Inkrementieren eines Zählers (72), wenn die gemessene Intensität nicht geringer als der Schwellenwert ist; und
einer Einrichtung zum Bewegen des Einfallsstrahls radial zur Platte, um jede der mehreren konzentrischen optischen Servospuren zu ätzen.

10. Vorrichtung nach Anspruch 9, wobei die Detektoreinrichtung (60) aufweist:

eine zweite Linse (62), die in dem Pfad des abgelenkten reflektierten Strahls angeordnet ist; einen undurchsichtigen Schirm (64), der im wesentlichen in der Brennebene der zweiten Linse (62) angeordnet ist und eine im wesentlichen an dem Brennpunkt der zweiten Linse (62) angeordnete Blende (69) aufweist, wobei der Schirm (64) dazu dient, von der zweiten Linse (62) ausgehende nicht fokussierte Lichtstrahlen auszufiltern; und
einen Photodetektor (66), der auf der der zweiten Linse (62) gegenüberliegenden Seite des Schirms (64) und nahe an der Bl nde (69) positioniert ist, um in Signal mit einer Größe proportional zu der Intensität des di Blende (69) passierenden fokussierten reflektierten Licht-

strahls zu erzeugen.

11. Vorrichtung nach einem der Ansprüch 2 bis 10, wobei die Einrichtung zum Durchlassen von Licht, das linear in der ersten Polarisationsrichtung polarisiert ist, und zum Ablenken von Licht, das linear in einer Richtung senkrecht zu der ersten Polarisationsrichtung polarisiert ist, eine mehrlagige dielektrische Dünnfilm-Laser-Linienbeschichtung aufweist.

12. Verfahren zum Verifizieren jedes Striches in einer Vorrichtung zum Ätzen mehrerer konzentrischer optischer Servospuren (12, 14) um die Rotationsachse (16) einer magnetischen Speicherplatte (61) mit konzentrischen magnetischen Datenspuren (20) um die Rotationsachse (16), wobei jede optische Servospur (12, 14) mehrere in gleichen Abständen angeordnete Striche (18) aufweist, und wobei die Striche aufeinanderfolgend durch Ein/Aus-Modulation eines Lichteinfallsstrahls geätzt werden, der von einer Linse (54) auf die Platte fokussiert wird, wenn die Platte rotiert, und wobei ein Teil des Einfallsstrahls von der Platte während des Ätzens jedes Striches reflektiert wird, und das Verfahren die Schritte aufweist:

a) Kollimieren des reflektierten Anteils des Einfallsstrahls zum Erzeugen eines reflektierten Strahls;
b) Trennen des reflektierten Strahls von dem Einfallsstrahl;
c) Messen der Intensität des reflektierten Strahls und Vergleichen der gemessenen Intensität mit einem Schwellenwert; und
d) Erzeugen einer Anzeige für die Verifikation, wenn die gemessene Intensität nicht kleiner als der Schwellenwert ist.

13. Verfahren nach Anspruch 12, wobei der Schritt (b) die folgenden Schritte aufweist:

i) lineares Polarisieren des Einfallsstrahls in einer ersten Polarisationsrichtung vor dem Fokussieren des Einfallsstrahls auf die Platte;
ii) Ändern der Polarisation des reflektierten Strahls bezogen auf den Einfallsstrahl in der Weise, daß der reflektierte Strahl in einer Richtung senkrecht zu der ersten Polarisationsrichtung des Einfallsstrahls linear polarisiert wird; und
iii) Führen des Einfallsstrahls und des reflektierten Strahls durch einen Strahlteiler mit einer Einrichtung zum Durchlassen eines in der ersten Polarisationsrichtung linear polarisierten Lichtstrahls und zum Ablenken eines in einer Richtung senkrecht zu der ersten Polarisationsrichtung linear polarisiert n Lichts, wodurch der Einfallsstrahl durch den Strahlteiler hindurchgelassen und der reflektiert Strahl abgelenkt wird.

14. Verfahren nach Anspruch 13, ferner mit den Schritten:

i) wiederholtes Erzeugen einer Abbildung des geätzten Punktes auf der Oberfläche des Mediums aus dem reflektierten Strahl;
ii) Verarbeiten der erzeugten Abbildung, um die Größe des geätzten Punktes zu bestimmen; und
iii) Einstellen des Fokusses der Linse, wenn die Größe des geätzten Punktes einen vorbestimmten Toleranzwert überschreitet.

15. Verfahren nach einem der Ansprüche 12 bis 14, wobei die Vorrichtung zum Ätzen ferner aufweist:

eine Optik (40) zum Erzeugen des Lichteinfallsstrahls zum Ätzen der optischen Servospuren; und
eine Spindel (59) mit einem Rotationsmittelpunkt zum Drehen der Platte in der Nähe der Optik, wobei das Verfahren ferner das Ausrichten des Einfallsstrahls auf den Rotationsmittelpunkt der Spindel vor dem Ätzen der Servospuren mit den Schritten aufweist:
Befestigen einer fein geteilten Oberfläche auf der Spindel in der Nähe des Rotationsmittelpunktes der Spindel;
Drehen der fein geteilten Oberfläche auf der Spindel;
Fokussieren des Einfallsstrahls auf die rotierende fein geteilte Oberfläche, wobei ein Teil des Einfallsstrahls von der geteilten Oberfläche reflektiert wird und einen reflektierten Strahl bildet;
kontinuierliches Messen der Intensität des reflektierten Strahls zum Erzeugen eines periodischen Signals mit einer Frequenz, welche die Strahlposition relativ zu dem Rotationsmittelpunkt der Spindel angibt;
mechanisches Justieren der Position der Optik parallel zu der Spindel, bis das Signal eine maximale Zentrierung anzeigt; und
ferner bevorzugt den Schritt der Trennung des reflektierten Strahls von dem Einfallsstrahl vor dem Messen der Intensität des reflektierten Strahls aufweist.

Revendications

1. Appareil pour graver un point sur la surface d'un support magnétique pour diminuer la réflectivité dudit point et pour vérifier ladite gravure, comprenant :

une source de lumière (40), pour fournir un faisc au de lumière collimaté incident ;
une première lentille (54), située sur le chemin du faisceau incident transmis, pour mettr au point sur un point de la surface du support magnétique (61), le faisceau incident; le faisceau incident mis au point réagissant avec le support magnétique pour diminuer la réflectivité de la surface en ce point, une portion du faisceau incident mis au point étant réfléchie, ladite première lentille (54) collimatant le faisceau réfléchi et dirigeant le faisceau réfléchi en retour vers la source de lumière (40) ;
des moyens (53), pour séparer le faisceau réfléchi du faisceau incident et pour dévier le faisceau réfléchi ; et
des moyens formant détecteur (60), situés sur le chemin du faisceau réfléchi dévié, pour mesurer l'intensité du faisceau réfléchi et pour comparer l'intensité mesurée à une valeur de seuil, de façon qu'une gravure convenable soit vérifiée si l'intensité du faisceau réfléchi n'est pas inférieure à la valeur de seuil.

2. Appareil selon la revendication 1, dans lequel les moyens pour séparer et pour dévier le faisceau réfléchi comprennent :

un polariseur (46), positionné sur le chemin du faisceau incident, entre la source de lumière (40) et la première lentille (54), pour polariser linéairement le faisceau incident dans une première direction de polarisation ;
un séparateur de faisceau (52), positionné sur le chemin du faisceau incident, entre le polariseur et la première lentille (54), comportant des moyens pour transmettre la lumière polarisée linéairement dans la première direction de polarisation et pour dévier la lumière polarisée linéairement dans une direction orthogonale à la première direction de polarisation, le séparateur de faisceau (52) transmettant le faisceau incident ; et
des moyens (56), positionnés entre la première lentille (54) et le séparateur de faisceau (52), pour modifier la polarisation du faisceau réfléchi par rapport au faisceau incident, de façon que le faisceau réfléchi soit polarisé linéairement dans une direction orthogonale à la direction de polarisation du faisceau incident, provoquant ainsi la déviation du faisceau réfléchi par le séparateur de faisceau (52).

3. Appareil selon la revendication 1 ou 2, dans lequel le support magnétique (61) est positionné dans le plan focal de la premièr lentille (54).

4. Appareil selon l'une quelconque des rev ndications 1 à 3, comprenant en outre :

des moyens d formation d'imag (76), positionnés sur le chemin du faisceau réfléchi dévié, pour génér r, depuis le faisceau réfléchi, une image du point gravé sur la surface du support ; et
des moyens (74), pour traiter l'image générée pour déterminer la taille du point gravé ; et
des moyens pour régler le foyer de la première lentille (54) si la taille du point gravé dépasse une tolérance prédéterminée.

5. Appareil selon l'une quelconque des revendications 1 à 4, dans lequel le support magnétique (61) est un disque (10) ayant un axe de rotation (16) et comportant des pistes de données magnétiques concentriques (20) autour dudit axe de rotation (16) et dans lequel le disque (10) est positionné sensiblement dans le plan focal de la première lentille (54) et dans lequel l'appareil comprend en outre :

des moyens (59), pour faire tourner le disque autour de son axe de rotation ;
des moyens (44) pour moduler la source de lumière (40) pour être active ou non-active, pour graver consécutivement une pluralité de piqûres également espacées autour de l'axe de rotation (16) du support (61), ladite pluralité de piqûres définissant une servo-piste optique (12, 14), lesdits moyens formant détecteur (60) étant destinés à vérifier chaque piqûre gravée consécutivement sur la piste ; et
des moyens pour déplacer le faisceau incident radialement par rapport au disque, pour graver chacune parmi une pluralité de servo-pistes optiques concentriques autour de l'axe de rotation du disque.

6. Appareil selon la revendication 5, dans lequel chaque servo-piste optique (12, 14) a un compte de piqûres prédéterminé et dans lequel l'appareil comprend en outre :

un compteur (72) ;
des moyens (70), pour incrémenter le compteur (72) à chaque fois qu'une piqûre est vérifiée ; et
des moyens (74), pour comparer le contenu du compteur (72) au compte de piqûres prédéterminé, de façon qu'une gravure convenable de chaque servo-piste optique soit vérifiée lorsque le contenu du compteur (72) est égal au compte de piqûres prédéterminé.

7. Appareil selon l'une quelconque des revendications 1 à 6, dans lequel les moyens formant détecteur (60) comprennent :

une deuxième lentille (62), situé sur le chemin du faisceau réfléchi dévié ;
un écran opaque (64), positionné sensiblement dans le plan focal de la deuxième lentille (62) t comportant un trou d'épingl (69) sensibl - ment au point focal de la deuxième lentille (62), ledit écran (64) étant destiné à bloquer les rayons de lumière non-mis au point sortant de la deuxième lentille (62) ; et
un photodétecteur (66), positionné sur le côté de l'écran (64) opposé à la deuxième lentille (62) et près du trou d'épingle (69), pour produire un signal ayant une amplitude proportionnelle à l'intensité du faisceau réfléchi dévié traversant le trou d'épingle (69).

8. Appareil selon la revendication 7, comportant en outre des moyens pour atténuer de manière réglable le faisceau réfléchi, pour protéger le photodétecteur (66) de dégâts dus à l'intensité du faisceau réfléchi pendant la gravure et pour permettre à ce même photodétecteur (66) d'être utilisé avec diverses intensités de faisceau incident et de faisceau réfléchi.

9. Appareil pour graver une pluralité de servo-pistes optiques concentriques (12, 14) autour de l'axe de rotation (16) d'un disque de stockage magnétique (61) ayant des pistes de données magnétiques concentriques (20) situées autour dudit axe de rotation (16), dans lequel chaque servo-piste optique (12, 14) comprend une pluralité de piqûres gravées également espacées (18) et pour vérifier le compte de piqûres de chaque piste, comprenant :

des moyens (59), pour faire tourner le disque autour de son axe de rotation ;
une source de lumière (40), pour fournir un faisceau de lumière collimaté incident ;
des moyens (44) pour moduler la source de lumière pour être active ou non-active, pour graver consécutivement la pluralité de piqûres également espacées de chaque dite servo-piste optique ;
un polariseur (46), situé sur le chemin du faisceau incident, pour polariser linéairement le faisceau incident dans une première direction de polarisation ;
un séparateur de faisceau (52), situé sur le chemin du faisceau incident, comportant des moyens pour transmettre la lumière polarisée linéairement dans la première direction de polarisation et pour dévier la lumière polarisée linéairement dans une direction orthogonale à la première direction de polarisation, l séparateur de faisceau (52) transmettant le faisceau incident ;
une première lentille (54), située sur le chemin du faisceau incident transmis, pour mettr au point le faisceau incident sur un point situé sur le disque magnétique, la première lentille (54) étant positionné d façon que le disque se trouve sensiblem nt dans le plan focal d la première lentille (54), le faisceau incident mis au point réagissant avec le support magnétique rotatif (61) pour créer une piqûre sur le support, ayant une réflectivité réduite ;
une portion du faisceau incident mis au point étant réfléchie, ladite première lentille (54) collimatant le faisceau réfléchi et dirigeant le faisceau réfléchi en retour vers le séparateur de faisceau (52) ;
des moyens (56) pour modifier la polarisation du faisceau réfléchi par rapport au faisceau incident, avant de revenir en traversant le séparateur de faisceau (52), de façon que le faisceau réfléchi soit polarisé linéairement dans une direction orthogonale à la première direction de polarisation du faisceau incident, provoquant ainsi la déviation du faisceau réfléchi par le séparateur de faisceau (52) ;
des moyens formant détecteur (60), situés sur le chemin du faisceau réfléchi dévié, pour mesurer l'intensité du faisceau réfléchi et pour comparer l'intensité mesurée à une valeur de seuil, et pour incrémenter un compteur (72) lorsque l'intensité mesurée n'est pas inférieure à la valeur de seuil ;
des moyens pour déplacer le faisceau incident de manière radiale par rapport au disque pour graver chacune parmi la pluralité de servo-pistes optiques concentriques.

10. Appareil selon la revendication 9, dans lequel les moyens formant détecteur (60) comprennent :

une deuxième lentille (62), située sur le chemin du faisceau réfléchi dévié ;
un écran opaque (64), positionné sensiblement dans le plan focal de la deuxième lentille (62) et comportant un trou d'épingle (69) sensiblement au point focal de la deuxième lentille (62), ledit écran (64) étant destiné à bloquer les rayons de lumière non-mis au point sortant de la deuxième lentille (62) ; et
un photodétecteur (66), positionné sur le côté de l'écran (64) opposé à la deuxième lentille (62) et près du trou d'épingle (69), pour produire un signal ayant une amplitude proportionnelle à l'intensité du faisceau réfléchi dévié traversant le trou d'épingle (69).

11. Appareil selon l'une quelconque des revendications 2 à 10, dans lequel les moyens pour transmettre la lumière polarisée linéairement dans la premièr direction de polarisation et pour dévier la lumière po-

larisé linéairement dans un direction orthogonale à la première direction de polarisation, comprennent un revêtement par laser de film mince diélectrique multicouches.

12. Procédé pour vérifier chaque piqûre dans un appareil pour graver une pluralité de servo-pistes optiques concentriques (12, 14) autour de l'axe de rotation (16) d'un disque de stockage magnétique (61) ayant des pistes de données magnétiques concentriques (20) situées autour de l'axe de rotation (16), dans lequel chaque servo-piste optique (12, 14) comprend une pluralité de piqûres également espacées (18) et dans lequel les piqûres sont gravées consécutivement par modulation d'un faisceau de lumière incident actif et non-actif, mis au point sur ledit disque par une lentille (54), pendant que ledit disque tourne, et dans lequel une portion dudit faisceau incident est réfléchie par le disque pendant la gravure de ladite piqûre, comprenant les étapes consistant à :

   a) collimater la portion réfléchie du faisceau incident pour produire un faisceau réfléchi ;
   b) séparer le faisceau réfléchi du faisceau incident ;
   c) mesurer l'intensité du faisceau réfléchi et comparer l'intensité mesurée à une valeur de seuil ; et
   d) fournir une indication de vérification si l'intensité mesurée n'est pas inférieure à la valeur de seuil.

13. Procédé selon la revendication 12, dans lequel l'étape (b) comprend les étapes suivantes :

   i) polarisation linéaire du faisceau incident dans une première direction de polarisation avant de mettre au point ledit faisceau incident sur ledit disque ;
   ii) modification de la polarisation du faisceau réfléchi par rapport au faisceau incident, de façon que le faisceau réfléchi soit polarisé linéairement dans une direction orthogonale à la première direction de polarisation du faisceau incident ; et
   iii) envoi du faisceau incident et du faisceau réfléchi à travers un séparateur de faisceau comportant des moyens pour transmettre un faisceau de lumière polarisée linéairement dans la première direction de polarisation et pour dévier la lumière polarisée linéairement dans une direction orthogonale à la première direction de polarisation, de façon que le faisceau incident soit transmis à travers le séparateur de faisceau et que le faisceau réfléchi soit dévié.

14. Procédé selon la revendication 13, comprenant en outr les étapes consistant à :

   i) générer d façon répétée, à partir du faisceau réfléchi, une imag du point gravé sur la surface du support ;
   ii) traiter l'image générée pour déterminer la taille du point gravé ; et
   iii) régler la mise au point de la lentille si la taille du point gravé dépasse une tolérance prédéterminée.

15. Procédé selon l'une quelconque des revendications 12 à 14, dans lequel ledit appareil de gravure comprend :

   des dispositifs optiques (40) pour générer ledit faisceau de lumière incident pour graver lesdites servo-pistes optiques ; et
   un mandrin (59), ayant un centre de rotation pour faire tourner ledit disque à proximité desdits dispositifs optiques, ledit procédé comprenant en outre l'alignement du faisceau incident avec le centre de rotation dudit mandrin, avant de graver lesdites servo-pistes, comportant les étapes consistant à :
   monter une surface finement réglée sur ledit mandrin, à proximité du centre de rotation dudit mandrin ;
   faire tourner ladite surface finement réglée sur ledit mandrin ;
   mettre au point ledit faisceau incident sur ladite surface finement réglée qui tourne, une portion dudit faisceau incident étant réfléchie par ladite surface réglée et formant un faisceau réfléchi ;
   mesurer en continu l'intensité du faisceau réfléchi pour produire un signal périodique ayant une fréquence indiquant la position du faisceau par rapport audit centre de rotation dudit mandrin ;
   régler mécaniquement la position desdits dispositifs optiques parallèlement audit mandrin jusqu'à ce que ledit signal indique un centrage maximum ; et
   comprenant en outre au préalable l'étape consistant à séparer le faisceau réfléchi du faisceau incident avant de mesurer l'intensité du faisceau réfléchi.

FIG. 1

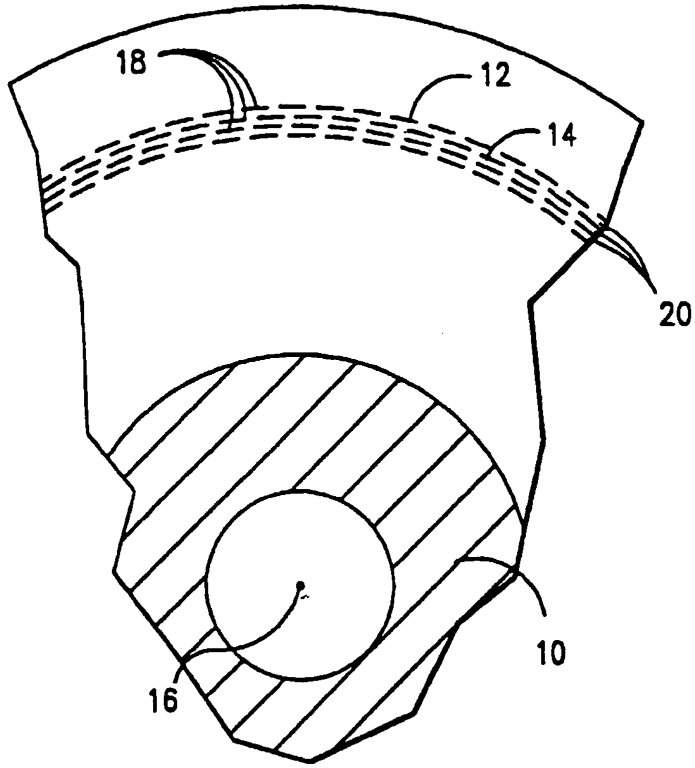


FIG. 3

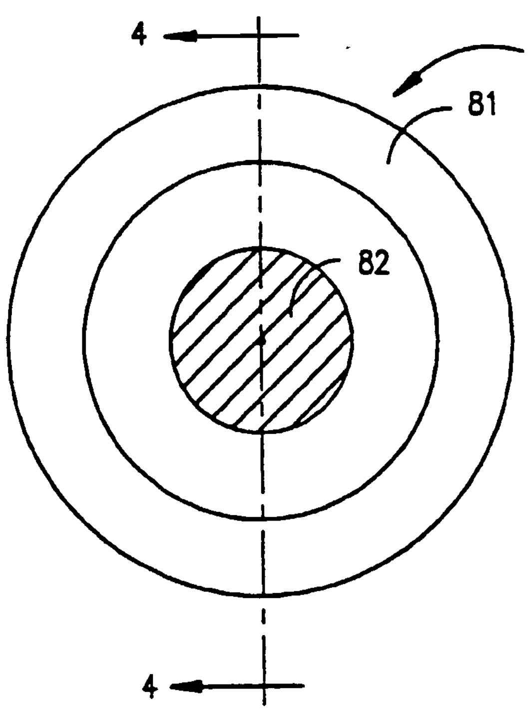
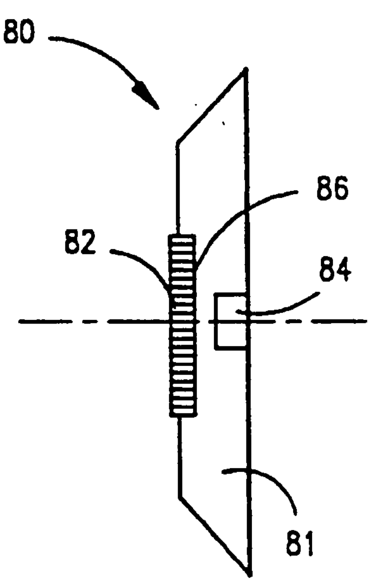


FIG. 4



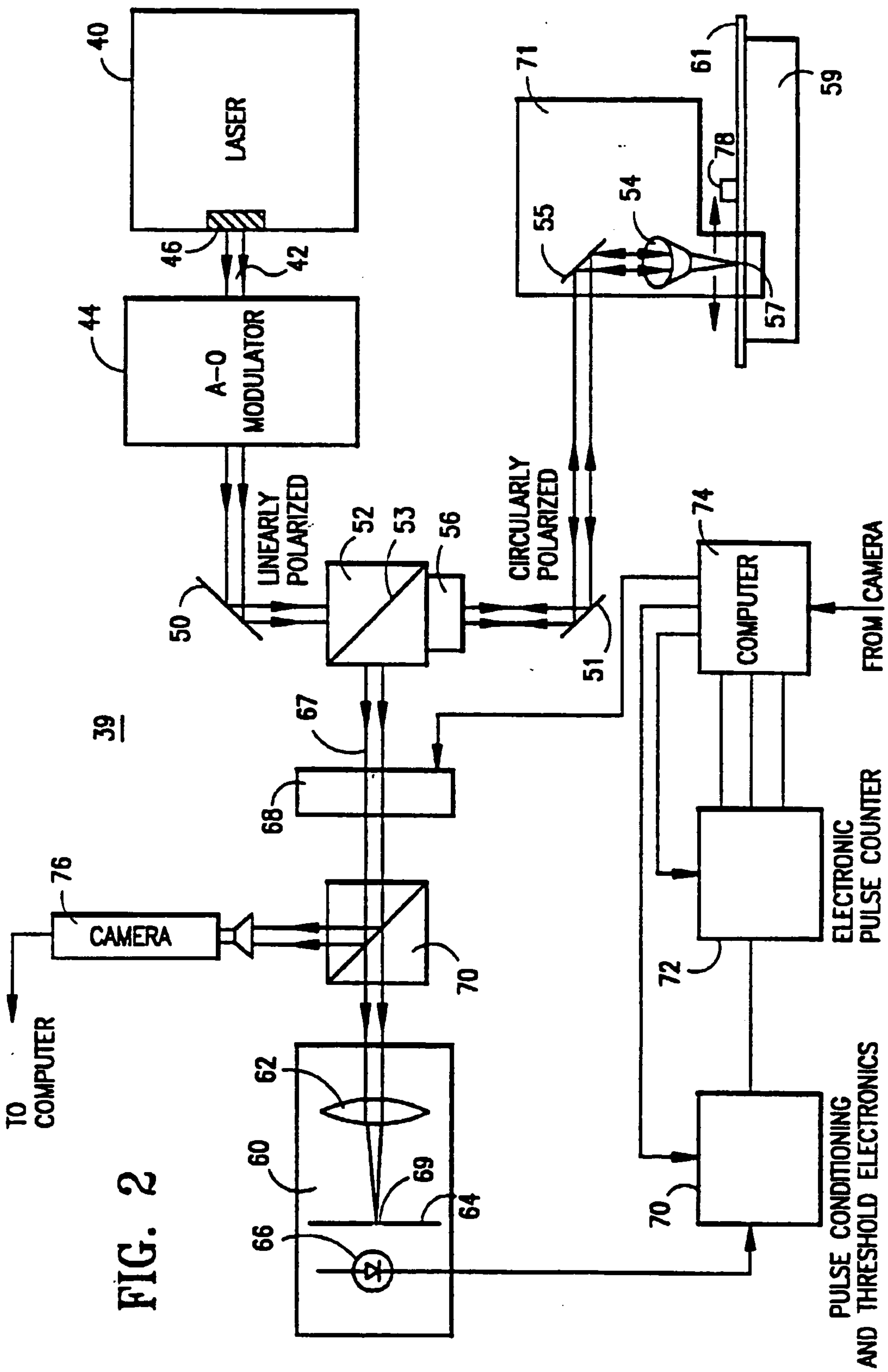
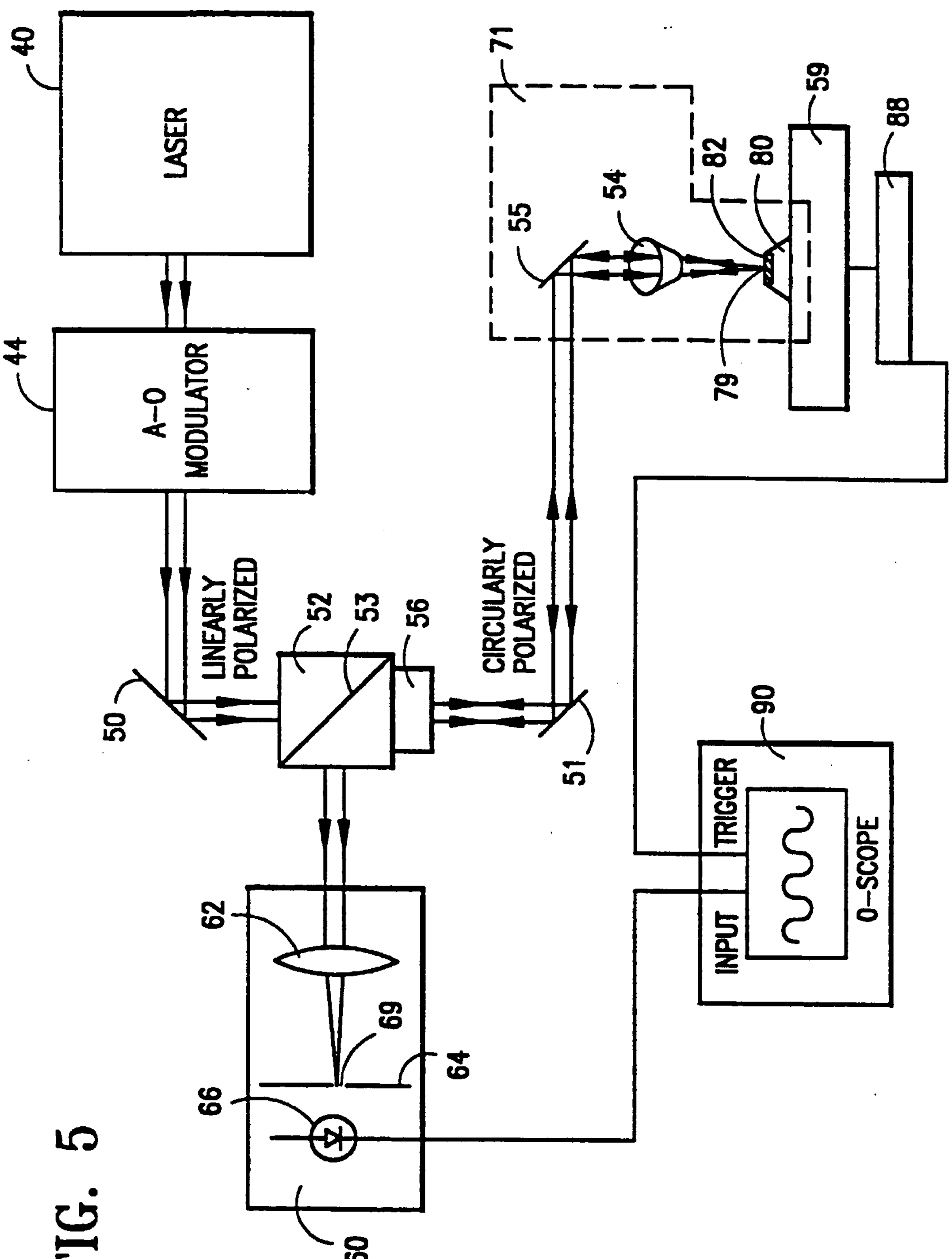

LASER
40
46
42
A-O MODULATOR
44
LINEARLY POLARIZED
50
52
53
56
CIRCULARLY POLARIZED
51
71
55
54
78
57
61
59
COMPUTER
74
FROM CAMERA
39
67
68
CAMERA
76
TO COMPUTER
70
ELECTRONIC PULSE COUNTER
72
62
60
69
64
66
PULSE CONDITIONING AND THRESHOLD ELECTRONICS
70

FIG. 2



LASER
A–O MODULATOR
LINEARLY POLARIZED
CIRCULARLY POLARIZED
TRIGGER
INPUT
O–SCOPE
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FIG. 5

FIG. 6

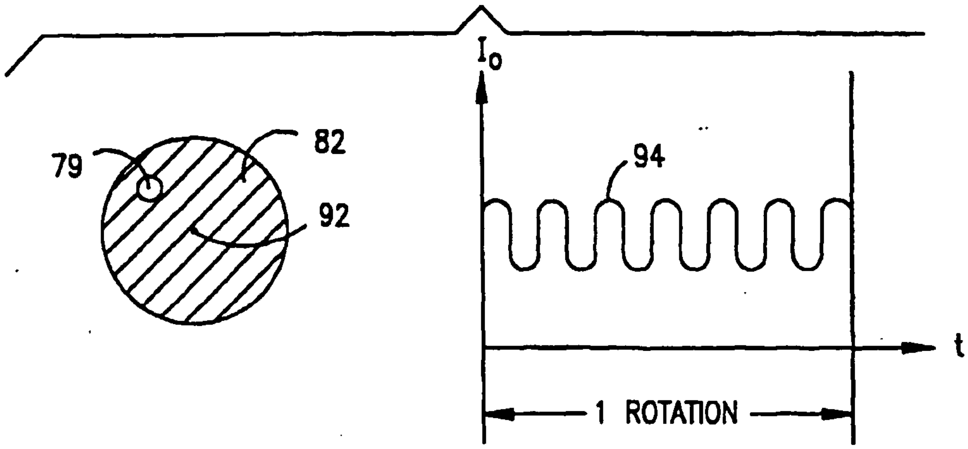

FIG. 7

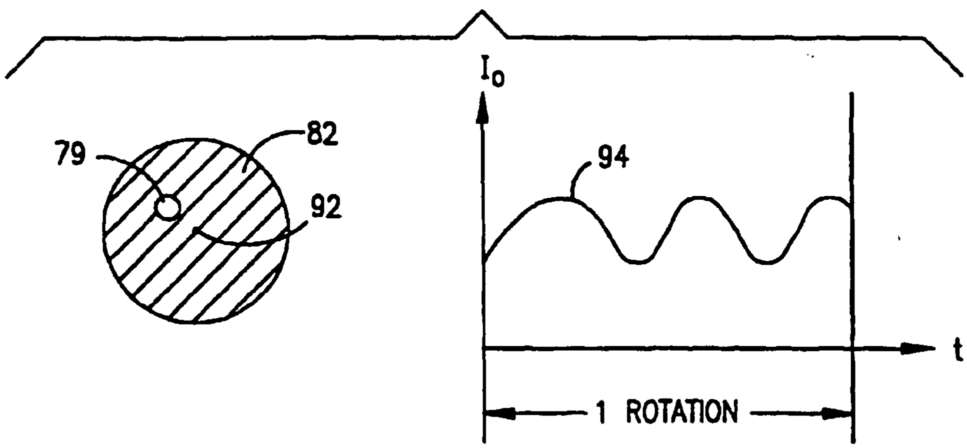

FIG. 8